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Review of chromatic disorder in the genus *Artibeus* (Chiroptera, Phyllostomidae), with new data for *A. lituratus* (Olfers, 1818)

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ABSTRACT. The known phenotypic variations in the coat of *Artibeus lituratus* include cases of of albinism, piebaldism and leucism. We are reporting a case of piebaldism in *A. lituratus* from the Atlantic Forest of the Pau-Brasil Environmental Protection Area, located in the municipality of Armação dos Búzios. The predominant vegetation in the region is 'restinga', a coastal ecosystem on Quaternary marine sandy deposits found along the Brazilian Atlantic coast. This study documents the third case of piebaldism in Brazil, emphasizing the incorrect use of leucism in the literature. Additionally, we provide a review highlighting piebaldism as the most common chromatic anomaly in bats of the genus *Artibeus*.

Keywords: Chiroptera, depigmentation, piebaldism, restinga, Sternodematinae

RESUMO – Revisão do distúrbio cromático no gênero *Artibeus* (Chiroptera, Phyllostomidae), com novo dado para *A. lituratus* (Olfers, 1818). As variações fenotípicas conhecidas na pelagem de *Artibeus lituratus* incluem casos de piebaldismo e leucismo. Aqui relatamos um caso de piebaldismo em *A. lituratus* da Mata Atlântica, na Área de Proteção Ambiental Pau-Brasil, localizada no município de Armação dos Búzios. A vegetação predominante na região é a restinga, um ecossistema costeiro sobre depósitos arenosos marinhos do Quaternário, ocorrendo ao longo da costa atlântica brasileira. O presente estudo registra o terceiro caso de piebaldismo no Brasil, reforçando o uso incorreto do leucismo na literatura, e disponibilizamos uma revisão que destaca o piebaldismo como a anomalia cromática mais comum em morcegos do gênero *Artibeus*.

Palavras chave: Chiroptera, despigmentação, piebaldismo, restinga, Sternodematinae

Diversity of color and patterns in mammal pigmentation is widely reported (Hoekstra 2006; Souza et al. 2013), with over 300 known genetic loci influencing pigmentation phenotypic in vertebrates (Oetting et al. 2009; Hofreiter & Schöneberg 2010). Among

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the phenotypes possible, chromatic anomalies exist, composed of pigments absent —such as albinism, leucism, and piebaldism —or exacerbated production —such as melanism (Hoekstra 2006; Lucati & López-Baucells 2017).

Albinism is the most well-known chromatic anomaly; it is a recessively inherited hypopigmentary disorder characterized by a complete lack of melanin due to the absence of the enzyme tyrosinase, which is a key component in melanin pigment production (Hoekstra 2006; Abreu et al. 2013; Lucati & López-Baucells 2017). Albino individuals are identified by their pale skin, white fur, and red eyes (Hoekstra 2006; Fertl & Rosel 2009).

Another chromatic anomaly is leucism, characterized by the absence of melanin in individual body structures, causing the animal to have complete white coloration, but the eyes have normal pigmentation (Jehl 1985; Lucati & López-Baucells 2017). Leucism results from a genetic mutation in the pigment transfer process, leading to the normal production of tyrosinase and melanin but preventing its deposition in skin cells and hair follicles, causing different phenotypes. Some of these phenotypes are similar to albinism despite having different causative mutations (Jehl 1985). Piebaldism is a type of hypopigmentation in which the absence of melanin pigment is localized in the skin and hair follicles due to genetic mutations (Lucati & López-Baucells 2017). Piebaldism is similar to leucism but differs in that it disrupts melanocyte development locally, leading to irregular white patches on the body while the eyes maintain their natural coloration (Davis 2007; Abreu et al. 2013).

Although rare in nature, such anomaly phenotypes have already been documented in several species of mammals worldwide (Brito & Valdivieso-Bermeo 2016; Talamoni et al. 2017). In the order Chiroptera, albinism, leucism, and piebaldism are known to occur, documented in species from different families (Boada & Tirira 2010; Sánchez-Hernández et al. 2012; Muñoz-Romo et al. 2014; Lucati & López-Baucells 2017).

Artibeus lituratus (Olfers, 1818) is one of the most common bats in the phyllostomid family, and is a part of the subfamily Stenodermatinae (Díaz et al. 2021). This species is found in Mexico, southern Brazil, northern Argentina, Bolivia, Trinidad and Tobago, the southern Lesser Antilles, and Trés Marías Islands (Reis et al. 2017). The species is the largest within its genus, exhibiting two very prominent supraocular and infraocular facial lines. The tragus and the lower part of the ears are typically very pale, generally cream or yellowish (Díaz et al. 2021). It usually displays a chocolate-brown coloration dorsally and a lighter ventral body compared to the dorsal side (Rui et al. 1999; Reis et al. 2017; Díaz et al. 2021).

Phenotypic variations in the pelage of *A. lituratus* are documented, including independent cases of albinism in Mexico (Zalapa et al. 2016), piebaldism in Colombia (Pérez-Torres [in prep.] as cited in Lucati & López-Baucells 2017) and Mexico (Zalapa et al. 2016). Additionally, there are occurrences of leucism reported in Colombia (Velandia-Perilla et al. 2013; Olarte-González et al. 2014), Mexico (López-Wilchis & León 2012; Sánchez-Hernández et al. 2012; García-Morales et al. 2013), and Brazil (Souza et al. 2013). Here, we report a recent case of piebaldism in a specimen of *A. lituratus* from the Atlantic Forest of the state of Rio de Janeiro, Brazil.

The study region is situated on an oceanic peninsula east of the state of Rio de Janeiro in the Environmental Protection area ('Área de Proteção Ambiental' - APA) Pau-Brasil (latitude -22.8071; longitude -41.9600), municipality of Armação dos Búzios, positioned within the coastal zone (Fig. 1). It was established by State Decree 31.346, issued on June 6, 2002 (INEA 2023). The predominant vegetation in the area is the 'restingas', a coastal ecosystem found on Quaternary marine sandy deposits along the Brazilian Atlantic coast (Alves et al. 2007).

The samplings were conducted over five nights, from April 20 to 25, 2023. Each capture night involved placing ten mist nets (9 x 2,5 m) along existing trails in APA Pau-Brasil, in clearings within the vegetation and near water streams. These nets remained open for six hours each night, starting from sunset, and were checked at 15-minute intervals (de Oliveira et al. 2020). Chiropterans captured were identified at the species level using external morphological characteristics with species identification keys (Reis et al. 2017; Díaz et al. 2021).

The study was conducted under a license granted by the Instituto Estadual do Meio Ambiente (INEA N° 004/2023), and the collected *A. lituratus* specimen (Voucher MN92342) was deposited in the Mammal Collections of the Department of Vertebrates at the Museu Nacional / UFRJ in Rio de Janeiro. A bibliographic search was conducted on the CAPES, Scopus, Scielo, and Google Academic databases to investigate previous records of chromatic disorders in Chiroptera from Mexico, Central America, and South America. The keywords used were "piebaldism", "leucism", "albinism", "hypopigmentation", and "chromatic anomaly". These terms were consistently used in conjunction with "*Artibeus*", "bat", and "Chiroptera", in the English, Spanish, and Portuguese languages.

Artibeus lituratus was the second most abundant species in the present study, with 16 records, following only *Desmodus rotundus* with 33 records, which supports findings from previous studies conducted in the 'restingas' area (Luz et al. 2011; Bôlla et al. 2017). In the same region, we captured an individual of *A. fimbriatus*, a species that may share measurements with *A. lituratus* but can be distinguished by the color of the coat, the less visible facial stripes, the brown edges of the ears and tragus, as well as by cranial characteristics (Rui et al. 1999; Pereira et al. 2017).

One male adult specimen of *A. lituratus* (forearm of 70.51 mm, weight of 73 grams) exhibited a chromatic disorder (depigmentation) on the wing, ear, nasal leaf, rostrum, back, and venter (Fig. 2). Our *A. lituratus* specimen features a long, dorsally flattened rostrum. The supraorbital and postorbital ridges, as well as the preorbital and postorbital processes, were well-developed and prominent. The mandible had a wide angular process and a non-prominent articular process, aligning with findings in the literature for this species (Rui et al. 1999; Araújo & Langguth 2010).

In the literature, we discovered three instances of piebaldism in *A. lituratus*, seven cases of leucism and one of albinism (Table 1). However, only one of the leucism record was according with the anomaly's description. The others, including the two records in the state of Rio de Janeiro in Brazil, are classified as cases of piebaldism, according to Lucati & López-Baucells (2017; Table 1). There is a clear lack of standardized nomenclature for the chromatic disorder in the reported cases, particularly concern-

ing piebaldism. This disorder is the most prevalent among bats worldwide (Lucati & López-Baucells 2017). However, it is often incorrectly labeled as other disorders, such as "leucism" or "partial albinism" (Table 1), and this misclassification is widespread worldwide (Lucati & López-Baucells 2017).

So far, there is no evidence that chromatic disorders are a disadvantage to bats, with no known influence on survival and reproductive success (reviewed by Lucati & López-Baucells 2017). Apparently, there are no differences in external morphology (Bravo-Salinas & Salas 2022). Various bat species affected by hypopigmentation have been reported to survive for multiple years worldwide (Lucati & López-Baucells 2017), with no reported influence on social behavior (Uieda 2001). On the other hand, other vertebrates with hypopigmentation are prone to experiencing a negative effect on fitness (Møller & Mousseau 2001; Caro 2005; Lucati & López-Baucells 2017). As Chiroptera usually inhabit dark places —such as caves, hollow trees, foliage, and abandoned buildings— and are primarily active at night, color disturbances appear to have no effect on the predation or social behavior of these species (Uieda 2000; Lucati & López-Baucells 2017).

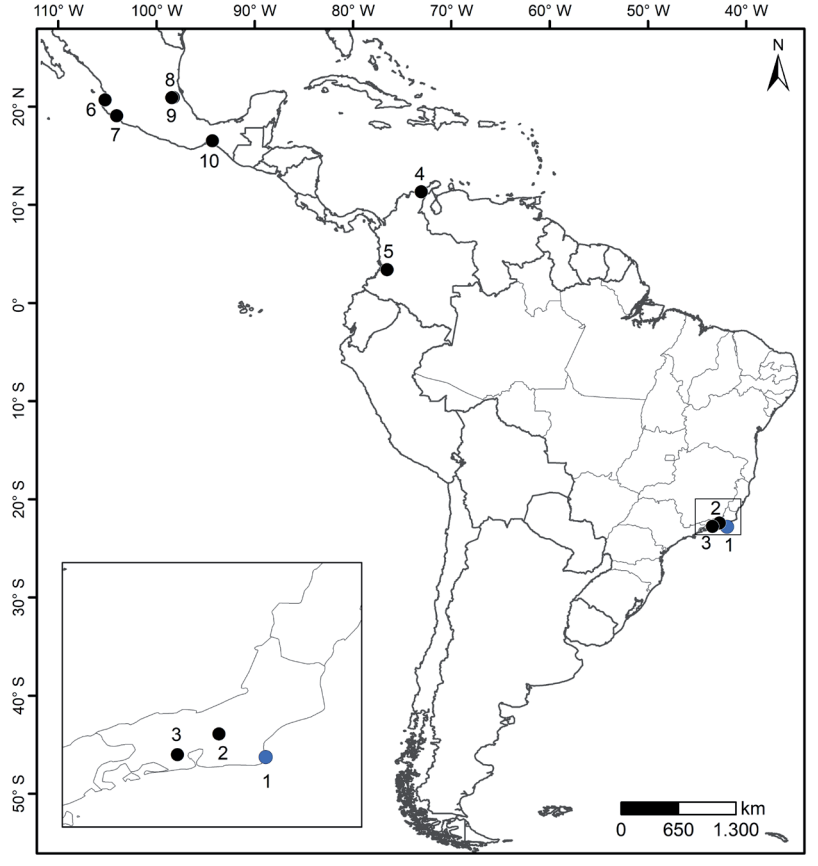

Figure 1. Map showing the localities of the cases of chromatic disorders in *A. lituratus*. Brazil, Rio de Janeiro state: 1) Armação dos Búzios, APA Pau-Brasil; 2) Cachoeiras de Macacu; 3) Nova Iguaçu. Colombia, Magdalena department: 4) PNN-Tayrona; Valle del Cauca department: 5) Santiago de Cali. Mexico, Jalisco state: 6) Puerto Vallarta; Colima state: 7) Manzanillo, Agua Blanca; Hidalgo state: 8) Huautla; 9) Yahualica, Zoquitipan; Oaxaca state: 10) Santo Domingo Zanatepec.

Figure 2. Piebaldism in *Artibeus lituratus*. (A) head; (B) part of the venter and right wing; (C) dorsal view. Depigmentation is visibly present on the ear, nasal leaf, face, wings, ventral and dorsal views.

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Table 1. Species of the genus *Artibeus* that present chromatic disorder in Mexico, Central America, and South America, specifying the species, collecting locality, sex (S), type of the anomaly, and font. ♀: Female, ♂: Male.

Taxon	Locality	S	Type	Font
Stenodermatinae				
Artibeus amplus Handley, 1987	Colombia: Caquetá	-	Piebaldism	Marín-Vásquez et al. 2013 apud García-Restrepo et al. 2023
	Venezuela: Tachira, Pregonero	-	Leucism	Muñoz-Romo et al. 2014
Artibeus anderseni Osgood, 1916	Peru: Manu	♂	Leucism*	Tello et al. 2013
Artibeus cinereus (Gervais, 1856)	Brazil: Brasília, Planaltina, Estação Ecológica de Águas Emendadas	♂	Albinism	Oliveira & Aguiar 2008
Artibeus fraterculus Anthony, 1924	Ecuador: Los Ríos, Mangas Saiba	♂	Leucism	Fernández de Córdova et al. 2017
Artibeus intermedius Allen, 1897	Mexico: Quintana Roo, Baca Paila	♀	Albinism	Pozo & Escobedo-Cabrera 1998 apud Ventorin et al. 2021
Artibeus jamaicensis Leach, 1821	Cuba	-	Albinism	Silva-Taboada 1979 apud Lucati & López-Baucells 2017
	Cuba	♀	Albinism	Lucati & López-Baucells 2017
	Colombia: Archipelago of San Andrés, Providencia and Santa Catalina Islands	♂	Leucism	Marín-Vásquez et al. 2010
	Cuba: Havana, El Mudo	♂	Albinism	Moreno et al. 2020
	Mexico: Hidalgo, San Felipe Orizatlán, Generales Azuara	♂	Leucism*	García-Morales et al. 2012
	Mexico: Chiapas	-	Partial Albinism*	Hernández-Mijangos 2009 apud Ruelas et al. 2016
	Mexico: Manzanillo, Colima	♀	Partial Albinism*	Sánchez-Hernández et al. 2010
	Mexico: Guerrero, Cocula	♀♂	Leucism*	Sánchez-Hernández et al. 2012
	Mexico	♀♂	White spotting*	Aguilar-López et al. 2021
Artibeus lituratus (Olfers, 1818)	Brazil: Rio de Janeiro, Armação dos Búzios, APA Pau-Brasil	♂	Piebaldism	Present study
	Brazil: Rio de Janeiro, Cachoeiras de Macacu	♂	Leucism*	Souza et al. 2013
	Brazil: Rio de Janeiro, Nova Iguaçu	♂	Leucism*	Souza et al. 2013
	Colombia	♂	Piebaldism	Pérez-Torres (in prep.) apud Lucati & López-Baucells 2017
	Colombia: Magdalena, PNN-Tayrona	♂	Leucism*	Olarte-González et al. 2014
	Colombia: Valle del Cauca, Santiago de Cali	♀	Leucism*	Velandia-Perilla et al. 2013
	Mexico: Jalisco, Puerto Vallarta	♀	White spotting*	Zalapa et al. 2016
	Mexico: Jalisco, Puerto Vallarta	♀	Albinism	Zalapa et al. 2016

Continued

	Mexico: Colima, Manzanillo, Agua Blanca	♂	Piebaldism	Zalapa et al. 2016
	Mexico: Hidalgo, Huautla	♀	Leucism	Sánchez-Hernández et al. 2012
	Mexico: Oaxaca, Santo Domingo Zanatepec	♀♂	Leucism*	López-Wilchis & León 2012
	Mexico: Hidalgo,Yahualica, Zoquitipan	♀	Leucism*	García-Morales et al. 2013
	Mexico	♀	White spotting*	Aguilar-López et al. 2021
Artibeus obscurus (Schinz, 1821)	Brazil: Espirito Santo	♂	Albinism	Ventorin et al. 2021
	Ecuador: Orellana	♀	Leucism	Flores Salazar 2021
Artibeus phaeotis (Miller, 1902)	Guatemala: Petén, San Andrés	♂	Leucism	Trujillo & Barahona 2014
	Venezuela: El Hatico, Eastern Seboruco	♂	Albinism	García et al. 2020
Artibeus planirostris (Spix, 1823)	Brazil: Paraíba, Santa Terezinha	♀	Albinism	Leal et al. 2021
	Brazil: Ceará, Fortaleza	-	Albinism	Uieda 2000
	Colombia: Córdoba, Canalete, Chimborazo	♀	Leucism	Chacón et al. 2015
	Colombia: Córdoba, Tierralta, Pasacaballos	♀	Leucism	Chacón et al. 2015
Artibeus rosenbergi (Thomas, 1897)	Colombia: Valle del Cauca, Calima-Darién	♀	Leucism*	Velandia-Perilla et al. 2013
Artibeus watsoni Thomas, 1901	Mexico: Chiapas	-	Partial Albinism*	Hernández-Mijangos 2009 apud Ruelas et al. 2016

* Improper use of terminology and associated concepts in scientific literature, according to Lucati & López-Baucells 2017.

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